

A Systematic Review of the Latest Advancements on Structural Equation Modelling (SEM) Technique Focusing on Applications in Transportation Planning

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Abstract

Finding methods to develop transportation planning and accordingly attract more people to use sustainable transportation is one of the most important subjects for transportation planners and decision-makers in current studies. The Structural Equation Model (SEM) is a statistical approach to examining the relationship between observed variables and latent variables. SEM is not only a single process, but also a cluster of related statistical techniques. The potential of SEM techniques lies in the essence of several issues in transportation planning and in using it as a guide for authorities. The main aim of this study is to present a systematic review of the application of the SEM methods in the assessment of transportation planning in the past decades, consequently, encouraging researchers to further investigate.

After conducting a review of 47 articles published in high-quality journals, from 2011–2020, the recorded articles are clustered into three main groups; perception, satisfaction and loyalty, and behavior related to mode choice. Further, these three groups are classified according to numerous key perspectives, containing published year, type of transportation mode, sample size, software and method. The result of this review article shows that since 2018 the usage of SEM approaches has significantly increased for the evaluation of public transportation service quality. Furthermore, recall findings in this article are recommended for researchers such as the improvement of the application and practice of SEM utilize methods in terms of transportation planning research to avoid imprecisions in a future study, particularly addressing the problems related to public transportation.

Keywords

Structure Equation Modelling (SEM), transportation planning, application and tendency, systematic literature review

1 Introduction

The traffic externalities are generally created by the extensive utilization of private transportation. Therefore, policymakers and transportation planners need to introduce strategies to encourage and motivate more citizens to use transportation in a more sustainable manner (Ismael and Duleba, 2022). To achieve the goal of sustainability, including the accessible, economical, and environmentally friendly movement of people and goods. Transportation planning is one of the crucial aspects in the operation, management and provision of convenient services for different transportation modes. In addition to the above, the interaction of the community improves the level of quality of life, economic activities, safety and comfortability for all individuals which are important factors as well (Moslem et al., 2020; Mugion et al., 2018;

Ismael et al., 2019). Though researchers have learned from past issues, society still encounters several transportation problems compared to the previous decades, for instance, service quality, and the satisfaction of public transport users. Thus, now scholars can use new techniques to solve these problems with more confidence. In order to improve the quality of service and to find out the consistent decision for the customers, many methods were applied in the past literature and the Structural Equation Model (SEM) is one of the common techniques that has been used (Ismael and Duleba, 2021). The main aim of this article is to systematically review the application of Structural Equation Modelling (SEM) approaches in the area of transportation planning and sustainable transportation. An additional goal is to examine the latest advancement of SEM

in the field of sustainable transportation. Furthermore, this review paper may be very informative for other researchers in several different fields of planning and engineering by illustrating how SEM techniques are acceptable in the process of decision-making and planning. In addition to that, the knowledge of this article highlighted new and important information for SEM users. Moreover, this study is the first study in the field of transportation planning from the application of SEM viewpoint. The remaining of this article is structured as follows:

- Section 2 presents the background and literature review, including a short introduction to SEM and the application of SEM in transportation planning.
- Section 3 illustrates the methodology of the review of this article.
- Section 4 describes the descriptive analysis and discussion in terms of the application of SEM in perception, satisfaction and loyalty, and behavior mode choice, based on some important key perspectives.
- In the final section, conclusions and future work are shown.

2 Background and literature review

The Structural Equation Model is defined as an influential family multivariate analysis method, which identifies the relationships between observed variables and latent variables. Observed variables are variables that can be measured during the process of data collection, and latent variables cannot be measured directly, they should be connected to the observed variables. SEM is a confirmatory rather than an exploratory method to test the relationships between variables (Bag, 2015). Structural Equation Modeling consists of two basic components as the structural model and the measurement model (Civelek, 2018). One of the distinctive points between SEM and traditional statistical model is that, during modelling tests, SEM accounts for measurement errors and it can also incorporate relationships between latent variables and observed variables, in which the errors of measurement should be minimized. However, it is assumed in the conventional statistical analysis methods that measurement errors are neglected in the specified model as it is the default (Zhang et al., 2013). In addition, indicating that SEM is a covariance statistics method that includes more information compared to a correlation which is based on regression analysis, in some case, SEM is called covariance structural modeling. Moreover, Civelek (2018) stated

that SEM in a single model can measure direct and indirect relationships among casual variables, this is one of the most crucial reasons for the widespread use of SEM.

Several statistical packages have been developed to apply SEM, for example, EQS, R, AMOS, CALIS and LISREL, amid which AMOS is commonly used because of its suitability for analysis in all stages (Collier, 2020). A review study on the SEM software's concluded that the three analytical packages: Lavaan, AMOS, and LISREL to the same estimation approach almost resulted in equal outcomes. However, the selected software package depends on the researcher's choice to conduct the analysis (El-Sheikh et al., 2017).

According to many authors, different decision problems have been solved by applying SEM methods in numerous areas of human activities. For example, a review paper (Ghasemy et al., 2020) argued that 49 studies used the Partial Least Square and Structural Equation Model (PLS-SEM) in the field of higher education and found that the application of SEM methods had several advantages and is concerned many researchers. Meanwhile including some limitations in the application, Tarka (2018) concluded that SEM is too valuable and cannot be rejected, particularly in social science. Additionally, Golob (2003) stated that based on more than 50 studies that used SEM in travel behavior research, SEM is becoming commonly used. Without doubt, the application of SEM is not applicable for all transportation planning problems, however, it is another alternative for a well-organized travel behavior study. Xiong et al. (2015) argued the application of SEM in construction revealed that on the one hand, SEM is an influential technique for tackling complex issues in old research. On the other hand, SEM also might be a useful tool in construction research to evaluate the achievement of new technology and the acceptance of usage.

Undeniably, there are several researchers claimed in their studies that now SEM is confidently organized and is commonly applied in particular fields of transportation for instance urban transportation (Dell'Olivo et al., 2017). Eboli and Mazzulla (2007); Friman et al. (2001); Minser and Webb (2010) and Stuart et al. (2016) considered urban public transportation assessment to attract more demand for public transportation. Moreover, some other researchers focused on railway transportation service (Chou and Kim, 2009; Tripp and Drea, 2002), and even some studies emphasized SEM in airline transportation to assess the service quality of airline (Cheng et al., 2008; Kim and

Lee, 2011; Park et al., 2006; Saha and Theingi, 2009). It is proved that SEM techniques have been widely used currently in transportation planning researches and this can be seen in this article as well.

3 Methodology

Pieces of literature were collected in this paper on the SEM techniques applied in transportation planning. This was obtained by intensive seek in various reliable resources regarding transportation planning. For example, in the key database collection of Web of Science (WoS) and Google Scholar. Meanwhile, considering some keywords such as SEM, transportation planning, service quality assessment, SEM and perception, satisfaction and loyalty and behavior mode choice. In addition to these searches, the combination of the SEM with other models are also considered, for instance, SEM + discrete choice model (DCM) and SEM + other statistical methods. All selected papers were published between (2011–2020). Fig. 1 shows the methodological framework for this paper.

3.1 The process of selected articles and primary analysis

To achieve the goal of this review article, at the beginning 60 papers were found dealing with SEM in the transportation planning field. Then, based on the primary analysis 47 papers were selected. After that, chosen papers are clustered into three main groups published in four

main publishers, the first group is perception, including 16 papers, the second group is satisfaction and loyalty contain 17 papers, final group is behavior and mode choice involving 14 papers, as shown in Table 1.

3.2 Classification framework

Before beginning with the analysis of selected papers, the description of the classification framework is essential to find which relevant studies will be examined in more detail. Consequently, there are some key measures, which will help with a deep understanding of applying SEM in transportation planning. Moreover, it may have several important benefits for the scholar to find the trend of applying SEM in the transportation planning field. The key aspects are publication year, publishers, software, SEM (Structural Equation Modell) techniques, transport modes and sample size. The Elsevier publisher contributes the maximum amount of publications of applying SEM in transportation planning by 53%, followed by Springer Link 19, as presented in Fig. 2.

4 Analysis and discussion

From the descriptive analysis, Fig. 3 demonstrates the research publication based on the year and illustrated the time interval of 2011–2020. From the beginning of the year, the knowledge of applying SEM in the field was slight. The importance and the application of the technique in the field came into actuality in 2018 when decision makers

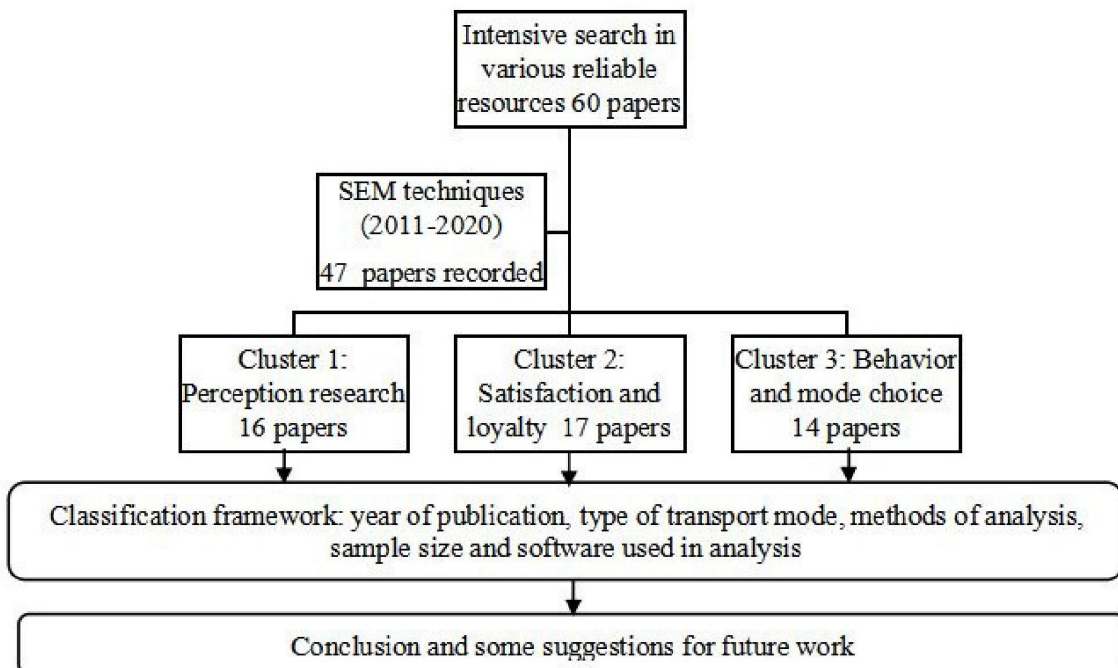


Fig. 1 Methodological framework

Table 1 Primary analysis of recorded articles

Sources	Specific field	Number of articles
(Agyeman and Cheng, 2020; Askari et al., 2021; Deb and Ali Ahmed, 2018; Eboli and Mazzulla, 2012; Friman et al., 2020; Javid et al., 2020; Jomnonkwo et al., 2020; Lättman et al., 2019; Munim and Noor, 2020; Rahman et al., 2016; Sarkar and Mallikarjuna, 2018; Su et al., 2021; Tiglao et al., 2020; Vallejo-Borda et al., 2020; Zhou et al., 2016; Zhou and Zhang, 2019)	Perception	16
(Allen et al., 2020; Allen et al., 2019b; Ahrholdt et al., 2019; de Oña, 2021; Eboli and Mazzulla, 2015; Efthymiou and Antoniou, 2017; Farooq et al., 2018; Ingvardson and Nielsen, 2019; Kamaruddin et al., 2012; Li et al., 2019; Ni et al., 2020; Shen et al., 2016; Soltanpour et al., 2020; Sun and Duan, 2019; Vicente et al., 2020; Yilmaz and Ari, 2017; Zhang, C. et al., 2019)	Satisfaction and loyalty	17
(Allen et al., 2019a; Daly et al., 2012; de Oña et al., 2016; Devika et al., 2020; Han et al., 2018; Hatamzadeh et al., 2020; Irtema et al., 2018; Jen et al., 2011; Lai and Chen, 2011; Lund et al., 2012; Mokarami et al., 2019; Shen and Chang, 2020; Si et al., 2019; Zhang, X. et al., 2019)	Behavior and mode choice	14

and transport planners understood the problems of development of sustainable transportation projects, especially in the aspects of stakeholder participation and the quality of service of sustainable transportation, the number of studies has been increased.

Fig. 4 reveals the usage of different software in analysis, so AMOS, SPSS has the highest percentage of usage. Collier (2020) suggested that to draw the structural equation model and graphical interface, AMOS is more friendly for design. In contrast, other SEM programs are almost all coding.

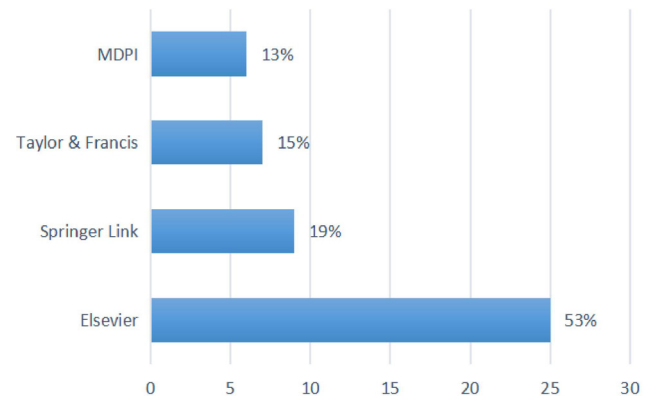


Fig. 2 Papers by different publishers

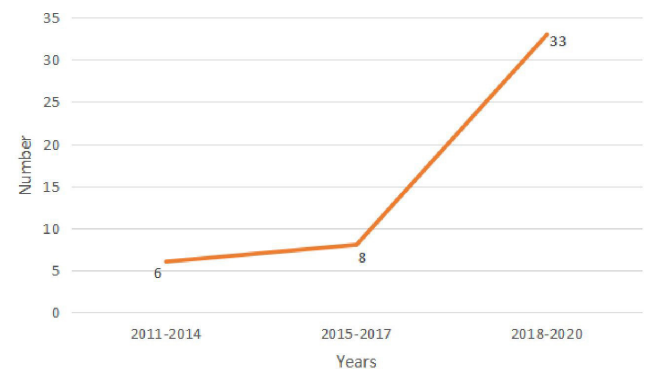


Fig. 3 Publications based on the year

■ SPSS, AMOS ■ SmartPLS ■ LISREL ■ R, STATA ■ BIOGEME, NLOGIT

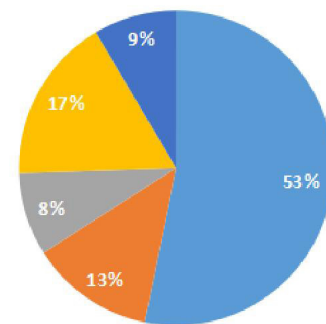


Fig. 4 Software used in the papers

According to Fig. 5, the covariance based methods have been commonly used in the literature by 25 papers, including factor analysis and maximum likelihood. As well as, partial least structure equation model is increasingly important based on the literature in the current researches.

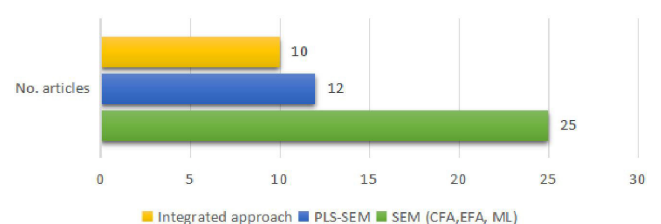


Fig. 5 The SEM technique in research articles

(Karimi and Meyer, 2014) discovered that both covariance based CB-SEM and partial least PLS-SEM are different methods during SEM estimation. However, in order to gain more accuracy in the results and imperial application, in more up-to-date studies, integrated approaches become more interesting for scholars in the field.

Regarding different transportation modes, Fig. 6 shows that almost all transportation modes were studied by researchers. Meanwhile, metropolitan transportation has the first rank in the examined studies, as it is the main source contributing several issues in cities, such as externalities.

In the last Fig. 7, the number of sample size is shown, in general, less than 1000 samples have been used for many studies, but above 1000 samples were also used in the literature. Nevertheless, there is no single number to use with the whole confidence, consequently, the selected sample size depends on the software, the methodology, the aim of the research as well as, the ability to collect samples and some suggested rules by researchers (Memon et al., 2020).

5 Conclusion and future work

This review article examined the latest development of SEM in transportation planning, which may help to improve sustainable transportation and assist decision makers and transportation planners. Therefore, 47 papers were reviewed for this purpose. In contrast, several limitations can be assumed in this paper, which can be solved or reduced in upcoming studies in this field. The key findings are that each SEM

technique has a different measurement approach and service quality, perception, satisfaction, loyalty and behavior intention have a diverse concept they should be examined alone. However, the impact of integrated modelling approaches has increased dramatically in recent studies. Therefore, future research directions should put efforts into hybrid modelling approaches, for example, mathematical approaches (MCDM) combine with statistical methods (SEM) or integration of two statistical approaches in designing SEM research for empirical studies. Conclusions of this review article are:

- The authors tried to cover almost all relevance researches that applied SEM in this field, but the selected papers for this review article have been published by 4 high-quality publishers (Taylor & Francis, Elsevier, MDPI, and Springer Link). Though, the authors accepted that there are several other studies, it is possible for future study to cover the full range of papers that applied SEM in the field.
- The current article covered relevant papers limited to three different clusters in transportation planning and according to some key aspects. Although, the authors in this research recommended studies that applied SEM in different specific fields of transportation planning with different aspects can be considered for future study such as, accessibility or other aspects to cover the entire system.
- This study also described the primary and taxonomy analysis. Future study can conduct the critical review of SEM methods or the relationship between and the influence of service quality, perception, satisfaction loyalty and behavior intention on the field.
- It is noticed that all software packages have different advantages and limitations of different methods. In contrast, further study is possible to examine the future development of software.
- Selected sample size is different in each research, thus, sample size depends on methods and software used and also on the ability to collect samples.
- Additionally, with in-depth research on SEM, its applications will be found widely. Thus, a review of the literature cited in this study will hopefully aid researchers in determining appropriate usage.
- It has shown that many scholars emphasized on urban transport mode. However, it is suggested to make a comparison between rural and urban transportation modes for future investigation.
- Finally, the previews points revealed from the review article that applied SEM is not the only method.

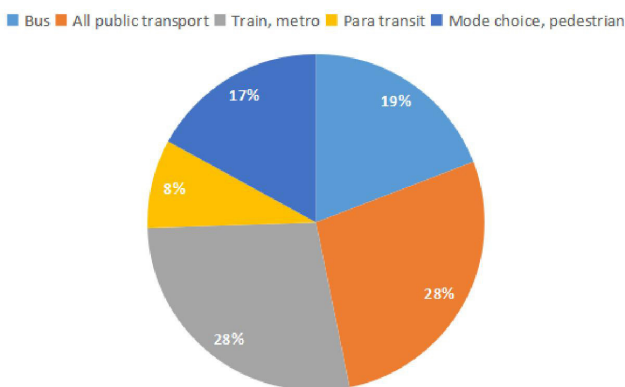


Fig. 6 Type of transportation modes

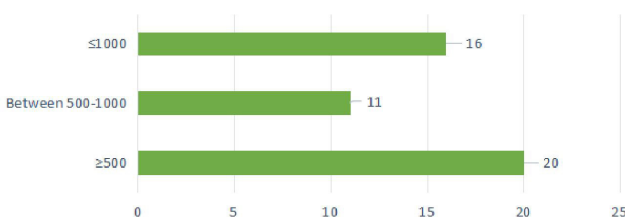


Fig. 7 Categories of sample size

Although, several opportunities for improving SEM have been shown, it can even be seen in up-to-date papers that the combined model with SEM has higher accuracy and a stronger ability.

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